REPORT DOCUMENTATION PAGE

AFRL-SR-BL-TR-01-

0597

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	10/02/01	Final Technical Report 9/1/99-2/28/01

4. TITLE AND SUBTITLE

(U) Computations of Droplet/Flow Interactions in Sprays

5. FUNDING NUMBERS

PE-61103D
PR-3484
SA-WS
~~F49620-00-1-0124~~
F49620-97-1-0525

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Room 732
Arlington, VA 22203-1977

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

20011203 181

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

The behavior of liquid fuel sprays was studied by direct numerical simulations. Two- and three-dimensional simulations were used to determine both the formation of drops and their interaction with the ambient flow. The Navier-Stokes equations were solved by a finite difference/front tracking technique that allowed resolution of inertial and viscous forces as well as the inclusion of surface tension at the deformable boundary between the fuel and the air. To examine the primary atomization and the formation of drops, several simulations of the breakup of sheared immiscible interfaces have been done. Two-dimensional simulations were used to examine the initial breakup and to establish the necessary numerical resolution. A three-dimensional code using cylindrical coordinates and local grid refinement has been used to examine how the initial two-dimensional instability becomes a fully three-dimensional "fiber" that eventually breaks up into drops.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Atomization, Spray, Generation of drops	3
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Final Report

~~F49620-00-1-0124~~
F49620-97-1-0525

The AASERT grant has supported the Ph.D. studies of Mr. Warren Tauber. Mr. Tauber is an excellent student and has done very well in his classes. He has given talks about his research at several meetings and co-authored one paper describing his results. Other papers are in preparation. However, Mr. Tauber has, suffered from health problems that have slowed down his progress. He seems to be over that now and did defended his thesis on September 7th 2001. The dissertation committee was unanimously in their opinion that Mr. Tauber had completed enough work to satisfy the degree requirement and he is currently writing his dissertation (funded as a teaching assistant).

Mr. Warren Tauber studies have focused on the atomization of a jet using direct numerical simulations using a front-tracking technique. Both two-dimensional and three-dimensional simulations of the Kelvin-Helmholtz instability of a small pie-shaped section of the jet are discussed. Unlike the Kelvin-Helmholtz instability for miscible fluids, where the sheared interface evolves into well-defined concentrate vortices if the Reynolds number is high enough, the presence of surface tension leads to the generation of folds that run parallel to the jet. While the initial growth rate is well predicted by inviscid theory, once the Reynolds numbers are sufficiently high, the large amplitude behavior is strongly affected by viscosity. Two-dimensional simulations were used to examine the initial breakup and to establish the necessary numerical resolution. A three-dimensional code using cylindrical coordinates and local grid refinement has been used to examine how the initial two-dimensional instability becomes a fully three-dimensional. These simulations have shown that initially axisymmetric waves on a jet will develop into narrow fingers that run parallel to the jet and eventually break into drops by a capillary instability. The axisymmetric waves are driven by the high shear between the jet and the ambient fluid. Eventually, viscous dissipation and separation of vorticity increases the thickness of the shear layer. The local shear becomes weaker and surface tension stops the waves from growing further. Three-dimensionality sets in as the axisymmetric waves start to retreat. Even though "fiber" breakup of jets takes place at relatively high Reynolds number, viscous effects appear to be critical for the generation of three-dimensional fibers.

The work has been described in the following journal papers:

W. Tauber; G. Tryggvason. Direct Numerical Simulations of Primary Breakup. *Computational Fluid Dynamics Journal.* vol.9 no.1, April 2000.

W. Tauber, S.O. Unverdi, and G. Tryggvason. The nonlinear behavior of a sheared immiscible fluid interface. Submitted to *Phys. Fluids*

W. Tauber and G. Tryggvason. Numerical Studies of Primary Atomization. Submitter to the International Journal of Multiphase Flow.